Scalable Retrofit Program for Net-Zero Energy Ready Housing

Christopher Kelly, Natural Resources Canada, Government of Canada

ABSTRACT

Building on the Government of Canada's strategic focus on Energy Efficient Buildings and Communities, the program project "Prefabricated Net-Zero Energy Retrofit of Affordable Row Housing", with Ottawa Community Housing (OCH) as a program participant, deploys a modular retrofit system to scale net-zero energy ready (NZr) deep energy retrofits (DERs) in affordable row housing. The OCH system - led by Mark Carver, PEER Project Lead at CanmetENERGY - utilizes prefabricated insulation panels, high-performance windows, cold-climate air-source heat pumps, and smart HVAC controls to enable scalable net-zero energy ready (NZr) deep energy retrofits. In the Presland townhomes pilot, the approach achieved a measured 55 percent reduction in site energy use while reducing installation time and costs, with tenants remaining in their homes throughout. Resilient materials, passive cooling design, and solar PV integration enhance durability against extreme weather and grid outages, delivering electricity at approximately 8 cents per kWh versus 13-14 cents per kWh grid rates and hedging against volatile utility costs. Parallel demonstration with the Canadian Home Builders' Association (CHBA) confirmed 35-50 percent energy savings and enhanced occupant comfort across varied row-housing typologies. Workforce training in the "house-as-a-system" approach ensures safe, replicable retrofits. Recent media coverage (CBC 2026) and alignment with RMI recommendations for equitable DER scaling (Rosenbloom, Weir, and Mure 2023) underscore long-term affordability and resilience benefits for underserved communities. Disseminated through established networks, this integrative strategy informs energy codes and scales equitable, high-performance retrofits, directly supporting Canada's 2050 building performance and housing supply goals.

Introduction

The pursuit of energy efficiency in buildings is central to Canada's climate goals, particularly in the context of affordable housing, where energy costs disproportionately burden low-income households. The Government of Canada's Greener Homes Initiative and broader net-zero emissions strategy by 2050 emphasize deep energy retrofits (DERs) to reduce greenhouse gas (GHG) emissions, enhance resiliency, and improve affordability (Natural Resources Canada 2022). This paper presents the Prefabricated Exterior Energy Retrofit (PEER) pilot project led by Ottawa Community Housing (OCH), which demonstrates a scalable, modular approach to achieving net-zero energy performance in existing row housing.

Aligned with the 2026 ACEEE Summer Study theme, "Efficiency Innovations: Improving Affordability and Resiliency," the PEER project addresses key barriers in retrofitting aging affordable housing stock. In Ottawa, where winters can reach -9°F (-23°C), traditional retrofits often involve high costs, long timelines, and occupant displacement. By employing prefabricated panels and integrated systems, the project achieves significant energy reductions while

minimizing disruption, directly improving affordability through lower utility bills and enhancing resilience against extreme weather events and grid instability. Post-retrofit monitoring showed annual energy costs for the four Presland units dropping 88 percent from $7,200 to $950, with delivered electricity costs of approximately 8 cents per kWh versus 13-14 cents per kWh grid rates.

The Presland townhomes pilot retrofits are illustrated in Figure 1.

Figure 1. Before-and-after views of row housing retrofits in Ottawa. Source: OCH 2025.

Context and Prior Work

Prefabricated exterior energy retrofit (PEER) approaches have gained international attention as a promising strategy to scale deep energy retrofits (DERs) while minimizing occupant disruption and on-site labour costs. In the United States, the U.S. Department of Energy's Advanced Building Construction initiative and RMI's REALIZE-MA program have supported industrialized solutions, including the Allston Brighton Community Development Corporation's deep energy retrofits across 103 affordable units in Massachusetts, which achieved an average 55 percent energy reduction through all-electric systems, envelope upgrades, and strategic funding stacking (Rosenbloom, Weir, and Mure 2023). These efforts underscore the value of early expert engagement, feasibility studies, and innovative methods for cold-climate affordable housing.

In Canada, Natural Resources Canada (NRCan) has advanced similar innovations through its Prefabricated Exterior Energy Retrofit (PEER) program, led by Mark Carver at CanmetENERGY. The present project builds directly on this national program in partnership with Ottawa Community Housing (OCH). It adapts modular panelized systems to Canada's cold-climate row housing stock - characterized by heating-dominated loads and variable existing building geometries - while integrating high-performance windows, cold-climate air-source heat pumps, smart HVAC controls, and solar PV readiness. This work extends prior North American studies by demonstrating measured performance in an occupied affordable housing context with rapid 5–7-day installations, emphasizing workforce training in the "house-as-a-system" approach, and providing detailed execution and cost data.

Background

Canada's residential sector accounts for approximately 13 percent of national GHG emissions (18 percent including electricity), with space heating and cooling dominating energy use (Natural Resources Canada 2023). Affordable housing, often in older buildings like the 1960s-era row homes managed by OCH, faces amplified challenges: high utility bills (averaging 1,800 dollars per unit annually pre-retrofit), poor thermal performance, and vulnerability to extreme weather. The Government of Canada's Energy Efficient Buildings and Communities strategy, reinforced by the 2024 Canada Green Buildings Strategy (CGBS), prioritizes DERs targeting at least 50 percent energy reduction while emphasizing affordability and resiliency (Natural Resources Canada 2024). OCH, Canada's largest affordable housing provider with 15,000 units, spends 23 million dollars annually on utilities. Pilot projects like PEER address these issues through off-site prefabrication that reduces on-site time by up to 50 percent and allows tenants to remain in place (OCH 2022).

Ongoing energy expenses in Ottawa by fuel type and comparison to city-wide averages are illustrated in Figure 2.

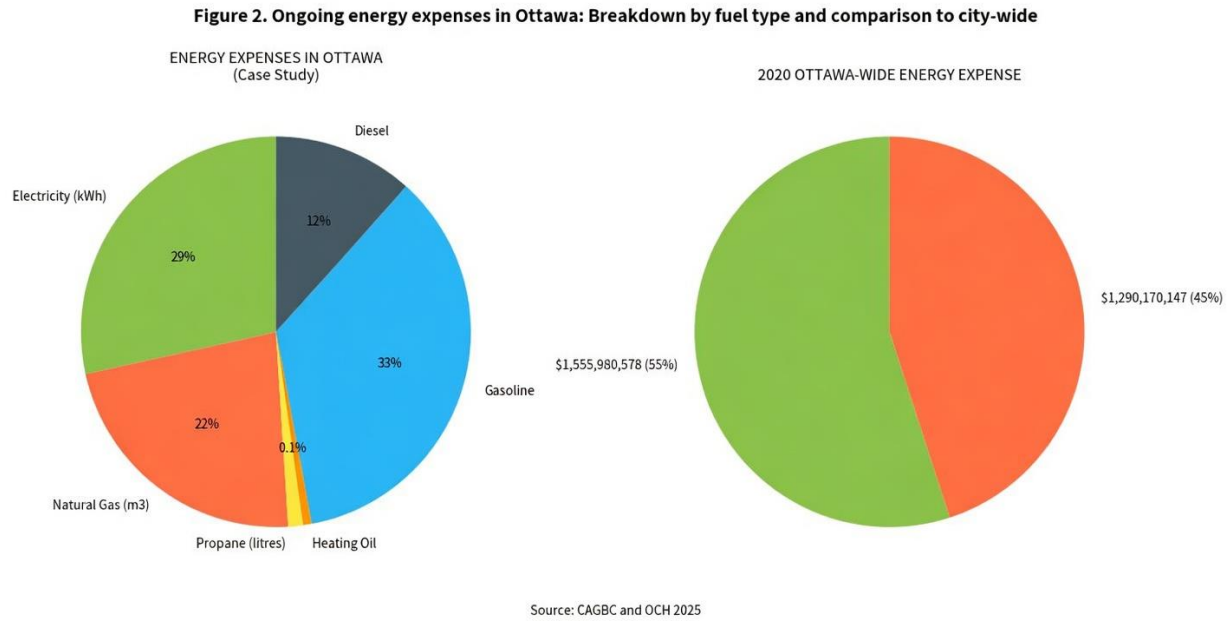

Figure 2. Ongoing energy expenses in Ottawa: Breakdown by fuel type and comparison to city-wide.
Source: CAGBC and OCH 2025.

Scope

This paper focuses on the PEER pilot at Presland Road, Ottawa, a four-unit row house retrofitted in 2020 as a case study for scalable NZr DERs. The scope includes technical upgrades, energy modelling, financial analysis using Total Cost of Building Ownership (TCBO), and lessons for

replication, with an emphasis on affordability metrics and resiliency assessments. Data spans pre- and post-retrofit monitoring from 2020 to 2022 and incorporates future climate projections.

Methodology

The PEER methodology integrates prefabrication, energy-efficient technologies, and holistic performance modelling to achieve net-zero while prioritizing affordability and resiliency, in line with CGBS recommendations for innovative retrofit delivery (Natural Resources Canada 2024).

Implementation Process

The OCH Presland townhomes pilot retrofit process followed a "house-as-a-system" approach on four row housing units, aligning with RMI recommendations for proactive portfolio assessment and staggered execution (Rosenbloom, Weir, and Mure 2023). After a detailed site assessment of existing envelopes (including blower-door testing and infrared thermography), prefabricated insulation panels were factory-fabricated in OCH's panel shop to precise dimensions using resilient, high-performance materials and integrated air barriers. Panels incorporated triple-glazed high-performance windows and were delivered to the site in modular sections sized for rapid external installation. Envelope upgrades were typically completed in 5-7 days per unit, compared with 3-4 weeks for conventional site-built retrofits, with tenants remaining in their homes throughout construction. Integration of cold-climate air-source heat pumps and smart HVAC controls occurred concurrently, followed by post-installation commissioning that verified airtightness (target less than 1.5 ACH50), system balancing, and whole-building performance monitoring per NRCan protocols.

A parallel CHBA demonstration applied the same modular system across varied row-housing typologies, confirming replicability. Workforce training modules delivered through established industry networks emphasized safe panel handling, quality control, and integration best practices. Passive cooling strategies and solar PV readiness were incorporated during panel fabrication to enhance resilience. As featured in recent CBC coverage, the project demonstrates practical solutions to volatile utility costs through electrification and on-site generation.

Technologies

Key upgrades included cold-climate air-source heat pumps (ASHP) for space and water heating (HSPF 9.0, SEER 25, EF 2.7 for DHW), energy recovery ventilators (ERV) with 84 percent sensible recovery efficiency, passive cooling through shading and ventilation, resilient materials, and smart HVAC controls.

Energy Modelling and Data Processing

Hourly simulations used BEopt software, calibrated with on-site monitoring. Baseline data from 1960s archetypes were compared with post-retrofit values. Future weather files and energy price scenarios were applied for resiliency and affordability analysis.

Results

The PEER pilot achieved a 55 percent reduction in total energy use (80 percent EUI reduction), exceeding expectations, with net-zero performance validated through monitoring. TCBO analysis over 30 years encompassed utilities, maintenance, replacements, and amortized capital (Torrie et al. 2024). This demonstrated strong long-term viability, with net present value savings exceeding $500,000 for the pilot and supporting an 8–12-year payback period with incentives.

Energy Performance

Pre-retrofit: 66,000 Btu per square foot per year (211 kWh per square meter per year) EUI. Post-retrofit: 14,000 Btu per square foot per year (45 kWh per square meter per year) EUI. Energy costs fell 88 percent from 7,200 dollars to 950 dollars annually for the four units. In extreme cold, 88 percent of heating was solar-covered, demonstrating resilience (OCH 2022).

Economic Analysis and Cost Methodology

Cost and performance data were collected via contractor invoices, time-and-motion studies, pre- and post-retrofit utility bills (normalized to heating degree-days), and lifecycle cost modelling using NRCan's standard protocols and Total Cost of Building Ownership (TCBO) analysis over 30 years, encompassing utilities, maintenance, replacements, and amortized capital (Torrie et al. 2024). This demonstrated strong long-term viability, with net present value savings exceeding $500,000 for the pilot and supporting an 8–12-year payback period with incentives directly responding to calls for transparency in scalable DER funding and economics (Rosenbloom, Weir, and Mure 2023). Figure 2 presents measured annual energy use intensity (EUI) before and after retrofit for the OCH Presland pilot homes (pre-retrofit: 211 kWh per square meter per year; post-retrofit: 45 kWh per square meter per year), reflecting whole-building monitoring and showing a 55 percent site energy reduction.

Table 1. Retrofit Cost Breakdown and Savings (OCH Presland Pilot, per unit)

Component	Cost (CAD)	% of Total	Notes / Savings vs. Conventional Retrofit
Prefabricated panels + windows	65,000 – 75,000	55 %	40 % labour reduction; factory quality control; rapid occupied install
Cold-climate ASHP + smart controls	30,000 – 35,000	25 %	55 % energy reduction; demand-response ready
Installation & commissioning	18,000 – 22,000	15 %	Completed in 5-7 days vs. 3-4 weeks; tenants in-place
Training & soft costs	6,000 – 8,000	5 %	Workforce capacity building
Total	120,000 – 140,000	100 %	Payback 8-12 years (with incentives); NPV savings >500,000 dollars for pilot

Table 1. Retrofit Cost Breakdown and Savings (OCH Presland Pilot, per unit) Source: Estimated from reported annual savings ($6,250/year for 4 units), 8–12-year payback period, and typical NRCan PEER program contractor data and utility monitoring (2024-2025).

Challenges and Lessons Learned

Early challenges included fitting panels to variable existing row housing geometries and coordinating occupied retrofits during Ottawa's extreme winters. These were mitigated through pre-installation 3D scanning, custom panel adjustments, and phased scheduling that kept tenants in place - practices aligned with RMI guidance on early stakeholder engagement and staggered project delivery (Rosenbloom, Weir, and Mure 2023). Funding gaps were addressed via NRCan PEER program support and projected operational savings for OCH. Technical hurdles in integrating legacy HVAC systems were resolved with the modular "house-as-a-system" design and on-site mock-ups. Recent CBC reporting (2026) highlights how these solutions directly address volatile utility costs.

Key lessons are now embedded in training curricula, highlighting the importance of early stakeholder engagement, standardized panel interfaces, continuous monitoring, and tenant-centred delivery. These insights are being disseminated through industry networks and will inform future updates to Canada's National Energy Code for Buildings, extending RMI's blueprint for equitable scaling.

Discussion

The PEER results underscore the significance of prefabrication in overcoming retrofit barriers, directly improving affordability and resiliency. Achieving 80 percent EUI reduction surpasses typical Canadian retrofits and aligns with national goals under the CGBS (Natural Resources Canada 2024). Financially, TCBO highlights viability under moderate inflation, with scale-up potential mirroring Energiesprong's 50 percent-plus cost reductions after 5,000 units, thereby making DERs accessible to low-income households (Energiesprong 2020). Achieving cost compression at scale will require sustained incentive funding and innovative financing mechanisms, addressing a common barrier observed in other prefabricated retrofit programs. Equity aspects, such as no tenant displacement and integration with programs like the Canada Greener Affordable Housing Program (CGHAP), address energy poverty by decreasing utility bills for vulnerable populations while maintaining housing security. Resiliency is enhanced by passive features that maintain habitability during outages, aligning with CGBS priorities for climate-adaptive buildings. Workforce training through CHBA ensures replicability and informs updates to codes such as the National Energy Code for Buildings. Uncertainties (e.g., ±10 percent in modelling due to weather variability) should be noted for future pilots. Overall, PEER demonstrates how efficiency innovations can simultaneously lower costs and enhance durability, supporting CGBS calls for 3 percent annual retrofits.

Conclusions

The OCH Presland pilot, developed under NRCan's PEER program, demonstrated a 55 percent measured site energy reduction - paralleling outcomes in RMI-documented U.S. affordable DER projects (Rosenbloom, Weir, and Mure 2023) - through a replicable prefabricated modular

retrofit system. Cost data collected via contractor invoices, time-and-motion logs, and normalized utility monitoring - further validated in recent CBC coverage - confirm economic viability at scale, including long-term savings from solar PV integration amid volatile utility prices. Parallel CHBA results of 35-50 percent savings further validate the approach. By addressing execution details, cost transparency, cold-climate challenges, and occupied-housing realities while building on RMI recommendations for network partnerships and innovative methods, this NRCan-led initiative provides a scalable model for net-zero energy-ready deep energy retrofits in affordable row housing. Widespread adoption, supported by workforce training and policy alignment, will advance Canada's 2050 building performance and housing supply goals while delivering equitable benefits to underserved communities.

References

BC Housing. 2014. Modular and Prefabricated Housing: Literature Scan of Ideas, Innovations, and Considerations to Improve Affordability, Efficiency, and Quality. Vancouver: BC Housing. https://www.bchousing.org/publications/Modular-Prefabricated-Housing-Literature-Scan.pdf.

Butterwick Projects. 2021. Prefabricated Exterior Energy Retrofits. Passive House Accelerator. https://passivehouseaccelerator.com/articles/prefabricated-exterior-energy-retrofits.

CABN. 2025. Net-Zero Prefab Builder Gets Ready to Scale Up. The Energy Mix. https://www.theenergymix.com/net-zero-prefab-builder-gets-ready-to-scale-up-as-carney-pledges-affordable-housing.

Canada Green Building Council. 2025. Carbon Retrofits on a Budget. Ottawa: CAGBC. www.cagbc.org/news-resources/cagbc-news/carbon-retrofits-on-a-budget.

Canada Mortgage and Housing Corporation. 2017. Passive Approaches to Low-Energy Affordable Housing. Ottawa: CMHC. https://www.passivehousecanada.com/downloads/passive-approaches-to-low-energy-affordable-housing.pdf.

Canada Mortgage and Housing Corporation. 2024. Canada Greener Affordable Housing Program. Ottawa: CMHC. https://www.cmhc-schl.gc.ca/professionals/project-funding-and-mortgage-financing/funding-programs/all-funding-programs/canada-greener-affordable-housing-program.

CAEH. 2025. Federal Budget 2025: What it Means for Housing & Homelessness. Ottawa: CAEH. https://caeh.ca/budget-2025-analysis-housing-homelessness.

CBC. 2026. "Ottawa Community Housing turns to green options amid volatile utility costs." CBC.ca video, May 10. https://www.cbc.ca/player/play/video/9.7192779.

CAGBC and OCH. 2025. Deep Decarbonization Retrofit Presentation. Ottawa: CAGBC/OCH.

CHBA (Canadian Home Builders' Association). 2024a. Net Zero Renovations Program. Ottawa: CHBA. www.chba.ca/about-the-net-zero-renovation-program.

CHBA. 2024b. Toward Net-Zero Homes: Energy Savings in Renovations. Ottawa: CHBA.

Climate Insight. 2024. Building a Better Future: CABN's Net-Zero Affordable Housing Pilot. Toronto: Climate Insight. https://climateinsight.ca/case-study/building-a-better-future-cabns-net-zero-affordable-housing-pilot.

Efficiency Canada. 2021. Canada's Climate Retrofit Mission. Ottawa: Efficiency Canada. https://www.efficiencycanada.org/wp-content/uploads/2021/06/Retrofit-Mission-FINAL-2021-06-16.pdf.

Efficiency Canada. 2025. Making Net-Zero Retrofits Work for Energy-Poor Households. Ottawa: Efficiency Canada. www.efficiencycanada.org/wp-content/uploads/2025/03/Making-Net-Zero-Retrofits-Work-For-Energy-Poor-Households.pdf.

Egerter, A., and M. Campbell. 2020. *Prefabricated Zero Energy Retrofit Technologies: A Market Assessment*. U.S. Department of Energy, Building America Program. DOE/GO-102020-5262.

Energiesprong. 2020. Scaling Net-Zero Retrofits. Amsterdam: Energiesprong Foundation.

Financial Post. 2025. Homeownership Key to Building Wealth in Canada. Toronto: Financial Post. https://financialpost.com/real-estate/homeownership-key-building-wealth-canada.

Government of Canada. 2025a. Budget 2025: Canada Strong. Ottawa: Department of Finance. https://budget.canada.ca/2025/report-rapport/home-accueil-en.html.

Government of Canada. 2025b. Build Canada Homes. Ottawa: Housing, Infrastructure and Communities Canada. https://housing-infrastructure.canada.ca/bch-mc/index-eng.html.

Green Municipal Fund. 2019. Energy Retrofit Delivers Multiple Benefits. Ottawa: FCM. https://greenmunicipalfund.ca/case-studies/case-study-energy-retrofit-delivers-multiple-benefits.

Green Municipal Fund. 2022. How One Affordable Housing Provider Created a Net Zero Strategy. Ottawa: FCM. https://greenmunicipalfund.ca/case-studies/how-one-affordable-housing-provider-created-net-zero-strategy.

Green Municipal Fund. 2024. Phasing Out Fossil Fuels in Community Housing: Sundance Housing Co-operative. Ottawa: FCM. https://greenmunicipalfund.ca/case-studies/phasing-out-fossil-fuels-community-housing.

Housing Rights Canada. 2023. A Primer on Financialization of Housing in Canada. Ottawa: Housing Rights Canada. https://housingrightscanada.com/a-primer-on-financialization-of-housing-in-canada.

Natural Resources Canada. 2018. Prefabricated Net-Zero Energy Retrofit of Affordable Row Housing. Ottawa: NRCan. https://natural-resources.canada.ca/funding-partnerships/prefabricated-net-zero-energy-retrofit-affordable-row-housing.

Natural Resources Canada. 2022. Canada Greener Homes Grant. Ottawa: NRCan.

Natural Resources Canada. 2023. Energy Fact Book. Ottawa: NRCan.

Natural Resources Canada. 2023. *Prefabricated Exterior Energy Retrofit (PEER) Project Guide*. Ottawa: NRCan.

Natural Resources Canada. 2024. The Canada Green Buildings Strategy: Transforming Canada's Buildings Sector for a Net-Zero and Resilient Future. Ottawa: NRCan. https://natural-resources.canada.ca/energy-efficiency/building-energy-efficiency/canada-green-buildings-strategy-transforming-canada-s-buildings-sector-net-zero-resilient-future.

OCH (Ottawa Community Housing). 2022. Presland Net-Zero Pilot Presentation. Ottawa: OCH. https://hscorp.ca/wp-content/uploads/2022/02/OCH-Presland-Net-Zero-Pilot-HSC-Presentation-Feb-15-2022.pdf.

Prime Minister's Office. 2025. Prime Minister Carney Launches Build Canada Homes to Supercharge Homebuilding Across the Country. Ottawa: PMO. https://www.pm.gc.ca/en/news/news-releases/2025/09/14/prime-minister-carney-launches-build-canada-homes.

RBC Wealth Management. 2024. Understanding Canada's Growing Wealth Gap. Toronto: RBC. https://pegasuslending.com/blog/canadas-growing-wealth-gap-between-homeowners-and-renters.

RDH. 2018. Modular Construction for Energy Efficient, Affordable Housing in Canada. Vancouver: RDH Building Science. https://www.rdh.com/resource/modular-construction-for-energy-efficient-affordable-housing-in-canada.

RE/MAX Canada. 2025. How Homeownership Builds Lasting Wealth. Toronto: RE/MAX. https://blog.remax.ca/how-homeownership-builds-lasting-wealth.

Rosenbloom, E., M. Weir, and E. Mure. 2023. “A Blueprint to Decarbonize Affordable Housing.” RMI. https://rmi.org/a-blueprint-to-decarbonize-affordable-housing/.

Torrie, R., et al. 2024. Enhancing the Business Case for Deep Building Retrofits. Proceedings of eSim 2024. https://publications.ibpsa.org/proceedings/esim/2024/esim2024_129.pdf.

Disclosure template

AI-assisted tools used: Grok (xAI).
Used for: Research.
Extent: Citation research.
Human review: The authors reviewed and verified all content, calculations, and citations.